MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

ERT3036 – ADVANCED ROBOTICS
(RE)
(OPEN BOOK EXAMINATION)

03 MARCH 2020
2:30 p.m. – 4:30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of **5 pages** including cover page with **4 Questions** only.

2. Attempt **ALL** questions. The distribution of the marks for each question is given.

3. Please write all your answers clearly in the answer booklet provided.

Question 1

(a) A mobile robot is differentially driven with wheel radius of **0.06 m**. The two wheels are separated by **0.4 m**. For each complete revolution of the wheel, the quadrature encoder gives **360 pulses**. q_1 and q_2 are the incremental encoder reading for wheel 1 (left wheel) and wheel 2 (right wheel) respectively. The coordinates of wheel 1 is resting at (0,0) at t = 0 with an orientation of $\phi = 0$ **radian**.

   (i) Calculate the pulses measured by q_1 and q_2 respectively when the robot is making **30 degrees** turn in the clockwise direction with an instantaneous radius of curvature, $R_i =$ **8 m**.

[4 marks]

   (ii) Calculate the coordinates of point P which is the mid-point between the two wheels along the differential drive axis.

[6 marks]

   (iii) The mobile robot will continue to rotate in the clockwise direction with an instantaneous radius of curvature, $R_i =$ **10 m**. Find the ratio of the wheel velocities, v_2/v_1, where v_1 and v_2 are the linear wheel velocities respectively.

[3 marks]

(b) The position of a differentially driven wheeled mobile robot is represented by point P. P is located at the mid-point along the axis connecting the two motors. The width between the two motors is $w =$ **0.5m** and its length is $L=$**1m**. The mobile robot is currently located at coordinates **(1.5m, 1.5m)** and it is going towards its goal at point G **(4m, 4m)**.

Circular obstacles with radius of $R =$ **0.5m** are located at point T_1 **(3m, 2m)** and T_2 **(1.5m, 3m)**. At this point, $R+s+L =$ **2.53m** and $R+s+2L =$ **3.53m**. s is the minimum distance of which mobile robot must stop in front of the edge of the obstacle before colliding with it. At this instant,

$$\overrightarrow{PG} = \begin{bmatrix} 2.5 \\ 2.5 \end{bmatrix}; \quad \|\overrightarrow{T_1 P}\| = 1.5811 \text{ m} \quad \text{and} \quad \|\overrightarrow{T_2 P}\| = 1.5 m$$

Find the navigation vector for the mobile robot at this point. [12 marks]

Continued …

Question 2

A serial robot with two links is shown in Figure Q2.
Point A is located at (0,0) at the x-z plane as shown (sagittal plane). Link 1 has a length of l_1 and mass of m_1 while link 2 has a length of l_2 and a mass of m_2. The angles of link 1 and link 2 with respect to the vertical z-axis are q_1 and q_2 respectively. The total kinetic energy for link 1 and link 2 is K_1 and K_2 respectively.

(a) Locate the coordinates for the centre of mass for link 1 and link 2.

[6 marks]

(b) Find K_2 when the moment of inertial for link 2 is I_2.

[12 marks]

(c) If $\begin{bmatrix} \dot{x}_{c1} \\ \dot{x}_{c2} \end{bmatrix} = J \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \end{bmatrix}$, find the matrix J.

[5 marks]

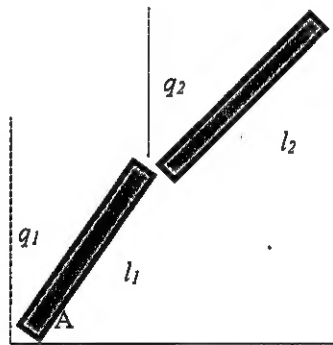(d) Provide the special name for matrix J and describe its function.

[2 marks]

Figure Q2. Two links serial Robot

Continued ...

Question 3

(a) With proper diagrams, explain the mechanism of how a quadrotor fly.   [2+5 Marks]

(b) Compare the good of having quadrotor in flying vehicle over fixed wing UAVs (Unmanned Aerial Vehicles).

[5 marks]

(c) A quadcopter has 4 identical motors providing a lifting force of $F = k_F \omega^2$ each. It was known that $k_F = 8 \times 10^{-8} \text{N/rpm}^2$, thrust to weight ratio is **2:1**, quadcopter weight is **500g**, carrying **4** LiPo Battery of **50g** each and a FPV camera of **150g**.

     (i)   Calculate the total thrust of the quadcopter.   [4 marks]

     (ii)   Calculate the thrust per motor.   [2 marks]

     (iii)   Calculate the speed of each motor for hovering action.   [2 marks]

(d) A team of **four (4)** quadrotors are taking off from the ground and flying in a square formation for **2 meters** in an indoor environment before landing again. Identify the hardware requirement and the lab setup to achieve this.

[5 marks]

Question 4

(a) Identify FIVE (5) human roles in human robot interaction and briefly explain EACH of them with ONE (1) task.   [5 + 5 Marks]

(b) Elaborate the term "Illustrator Cues" in human robot interaction.   [4 marks]

(c) Describe Robot's Ethics and state Zeroth Law of Robotic.

[3 + 2 marks]

(d) List down FOUR (4) Advantages of having Medical Surgical Robots.   [4 marks]

(e) Can Medical Surgical Robots fully replace human surgeon? Explain your answer.

[1 + 1 marks]

End of Paper ...